Beaked Whale Presence, Habitat, and Sound Production in the North Pacific

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LONG-TERM GOALS

The goal of this project is to study beaked whale presence and sound production in the North Pacific. The project is motivated by the need to better understand beaked whale distribution and habitat, and the need for classification of these species from passive acoustic data. By studying beaked whale presence, habitat and sound production, the Navy will be better prepared to conduct environmental impact assessments. In addition, fundamental information will be gained on beaked whale acoustic ecology.

OBJECTIVES

The objective of this project is to construct an abundance estimate and distribution map of beaked whale presence in the southern California region based on long-term passive acoustic monitoring data. Passive acoustic monitoring of beaked whales has only been developed over the last five years, as High-frequency Acoustic Recording Package (HARP) technology has made high frequency long-term acoustic monitoring practical (Wiggins & Hildebrand 2007). Better knowledge of beaked whale distribution and abundance is expected to lead to better understanding of the niche habitats of each beaked whale species, allowing use of environmental correlates to extrapolate distribution maps.

APPROACH

Beaked whale species distributions are presently mapped over broad geographic regions. Data on beaked whale distributions come from whaling off Japan, fishing net entanglements, visual surveys, and strandings. Visual survey sightings depend greatly on low sea states and sighting rates are low in part because the median dive time for beaked whales is long (e.g. Cuvier's beaked whales average 29 minute dives) and the median surface time is short (e.g. two minutes). In Beaufort one or lower sea states, only 23 percent of Cuvier's beaked whales on the trackline are estimated to be seen, and this sighting rate drops by an order of magnitude by sea state 5 (Barlow & Gisiner 2006).

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14. ABSTRACT

The goal of this project is to study beaked whale presence and sound production in the North Pacific. The project is motivated by the need to better understand beaked whale distribution and habitat, and the need for classification of these species from passive acoustic data. By studying beaked whale presence, habitat and sound production, the Navy will be better prepared to conduct environmental impact assessments. In addition, fundamental information will be gained on beaked whale acoustic ecology.

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Passive acoustic monitoring provides an alternate method for assessing beaked whale populations. With Navy support, we have been conducting long-term high frequency acoustic monitoring with HARPs in the southern California region for the past four years. These data reveal ample acoustic signatures from beaked whales. At least ten species of beaked whales have been known to occur in the northeast Pacific, mostly based on stranded animals. Acoustic signatures are positively known for four of these, though distinctive echolocation signatures likely exist for the others, and several new acoustic signatures have been found in the southern California recordings.

Cuvier's beaked whales produce characteristic echolocation sounds which are the same across and between ocean basins, (authors' unpublished data), even though there is evidence of genetic separation within this species between ocean basins (Dalebout *et al.* 2005). Cuvier's beaked whale produce frequency modulated echolocation pulses with mean inter-pulse intervals of 0.4 s and durations of about 200 µs. The upsweeps have center frequencies at 42 kHz and -10 dB bandwidths of 22 kHz (Zimmer *et al.* 2005).

While automated detectors have been used to detect beaked whales in autonomous data (Roch *et al.* 2008), such detectors are not available for the full range of beaked whales. An alternative approach is the use of spectral-averaging to search for acoustic events in long-term data sets (e.g. (Burtenshaw *et al.* 2004). Instead of inspecting short duration spectrograms for individual calls, successive spectra are calculated and averaged together. These averaged-spectra are arranged sequentially to provide a time series of the spectra. The averaging time determines the resolution of the resulting plot and the data compression factor. Depending on the number of samples used for the spectra and the averaging time used, data compression factors of 4000 or more are possible while still providing enough resolution to observe short-term events above the ambient noise. Long-term spectral averages allows the analyst to rapidly find times of potential calling events, and then these events can be manually examined at a finer time scale for classification. Other sounds likely to be confused with beaked whale echolocation clicks can be separated by manual viewing of the fine-scale spectrogram. For now manual inspection remains the best way to discover new acoustic signatures.

Our approach for population estimation is a cue count method. The basic unit for analysis is one foraging dive for either a group of beaked whales or a single beaked whale. Due to the highly directional nature of beaked whale echolocation, we do not expect to continuously detect the echolocation sounds, depending on which direction the animals are pointed. From the acoustic data, it is possible to estimate the number of echolocating animals in the group and thereby derive an acoustic estimate for group size. Likewise, at each recording site, it is possible to estimate the average number of foraging dives per day, and then compare these data to the dive rate observed with tag data. The overall density of Cuvier's beaked whales in the southern California study area can be estimated by first calculating the number of animals within the detection radius of each HARP, and then dividing by the effective monitoring area for the HARPs, following previously published analyses (Zimmer *et al.* 2008).

WORK COMPLETED

We have completed a detailed examination of 40 Terabytes of acoustic data covering about 1,200 instrument days of recording. In these data, over 2,000 Cuvier's beaked whale foraging dives have been detected. A subset of about 100 of these dives have been analyzed for echolocation group size.

RESULTS

Cuvier's beaked whales in the southern California data set show no obvious seasonal differences in their distribution; they do not appear to be migratory. Their preferred habitat is for water depths of at least 1000 m.
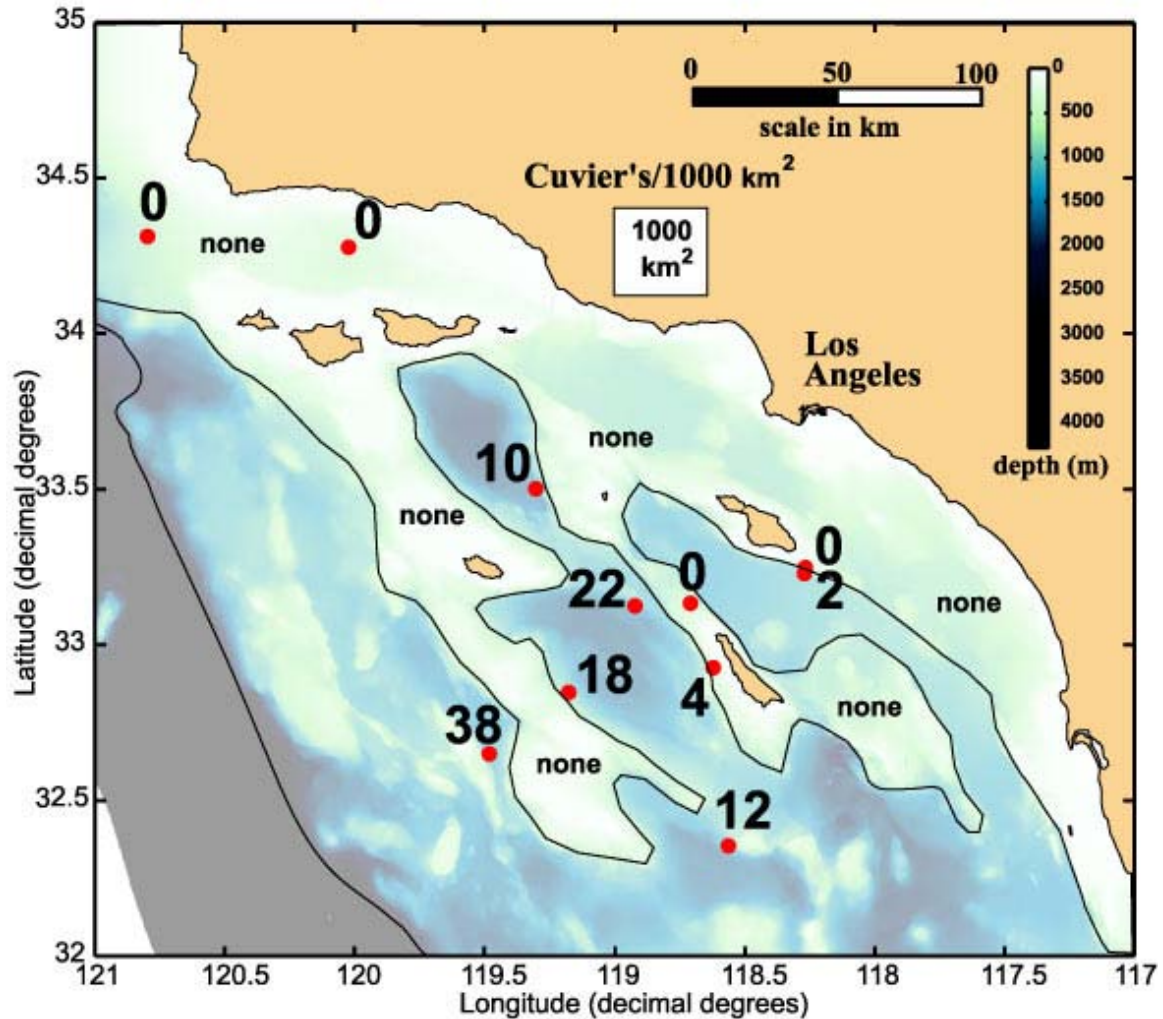

Figure 1. Cuvier's beaked whale densities are shown in animals per 1000 km².
Red dots indicate HARP deployment sites. Color shading gives bathymetric contours,
with 1 km water depth contour indicated.

A preliminary estimate of Cuvier's beaked whale densities has been completed for southern California HARP deployment sites (Figure 1). Using a diving rate of 8 dives/day, a group size of 2.4 animals, and an effective detection radius of 3.5 km, the average density of Cuvier's beaked whales in the southern California region is about 20 animals per 1000 km². This acoustic estimate of density is somewhat higher than published estimates based on visual survey data (e.g. NMFS, all California waters to 200 nm, Cuvier's beaked whale density = 3.8 animals per 1000 km².)

IMPACT/APPLICATIONS

The ability to conduct marine mammal population estimates using acoustic monitoring provides a complimentary means for study of population trends. This is particularly important in the context of monitoring naval training ranges, and the potential impact of range activities on marine mammal populations.

RELATED PROJECTS

Project title: Southern California Marine Mammal Studies; Sponsor: CNO N45 and the Naval Postgraduate School; Support from this project allowed for the development of HARP instrumentation and collection of the acoustic data processed for beaked whales with ONR support during N000140910489.

Project title: SBIR Topic N07-024 Marine Mammal Acoustics; awarded to Sonalysts; Sponsor: NavAir PMA264; Support from this project has allowed analysis of the sonar exposure level which causes Cuvier's beaked whales to stop foraging. This analysis currently includes 1606 Cuvier's dives from 728 recorder days and 770 hours of sonar exposure. The final report for the phase II base period is available and phase II option funds are being used to prepare a manuscript for a peer review publication.

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